



The Radio Amateur Satellite Corporation

AMSAT Education and You!

Mark Hammond, N8MH
Vice President for Educational
Relations

Orlando Symposium

October 2012



Acknowledgements:

Mark Spencer, WA8SME
Director ARRL Education & Technology Program



Why is education important to us?

- It's a part of our mission and vision!



Why is education important to us?

- AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes **space education**. We work in partnership with government, industry, **educational institutions** and fellow amateur radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.



Why is education important to us?

- Our Vision is to deploy satellite systems with the goal of providing wide area and continuous coverage. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the **educational community** and other amateur satellite groups.



Why is education important to us?

- Education has quickly become critical for our ride to space
- LOTS of educational tie-ins from K-16
 - » K-12 STEM education=CRITICAL
 - » University CubeSat missions
- AMSAT Fox-1, Fox-2, etc.
- ARISSat-2, 3, ?



Recent Educational Activities

- PACIFICON Convention
 - » ARISS Contact via telebridge 13 OCT 12
 - Joe Spier, K6WAO
 - Astronaut Dr. Lee Morin present
 - » ARRL Youth Forum activity
 - Fox-1 Cubesat paper models with EMike McCardel, KC8YLD
 - Cubesat simulator demonstration with Dale Hunzeker, KJ6VUC



Recent Educational Activities

- PACIFICON Convention
 - » Live portable satellite QSOs
 - with Tom Deeble, KA6SIP

 - » AMSAT Table
 - With Alan Bowker, WA6DNR



- Recently formed Educational Partnership between AMSAT and ARRL, including NASA

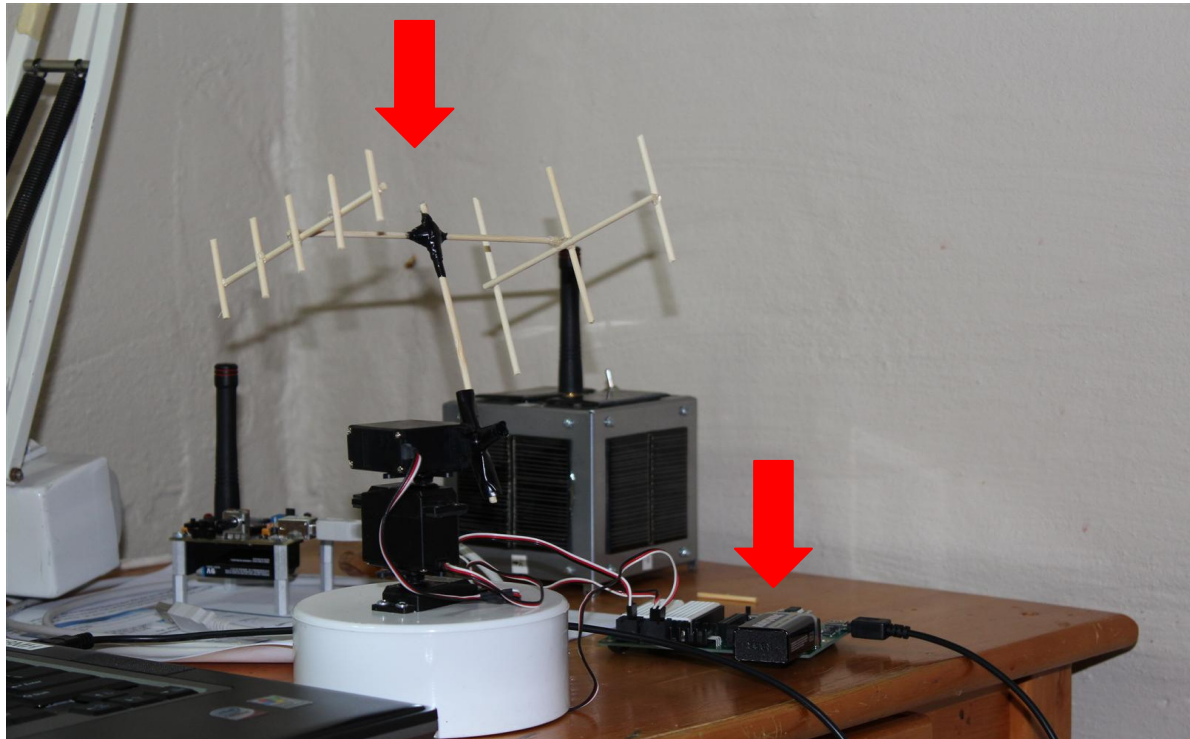


Other Educational Activities

- Tracking simulator
- Cubesat simulator
- Yaesu FT-817 Sat CAT controller
- MAREA- the Mars-lander ARISS Robotics Exploration Activity
 - » All thanks to Mark Spencer, WA8SME and ARRL-ETP partnership

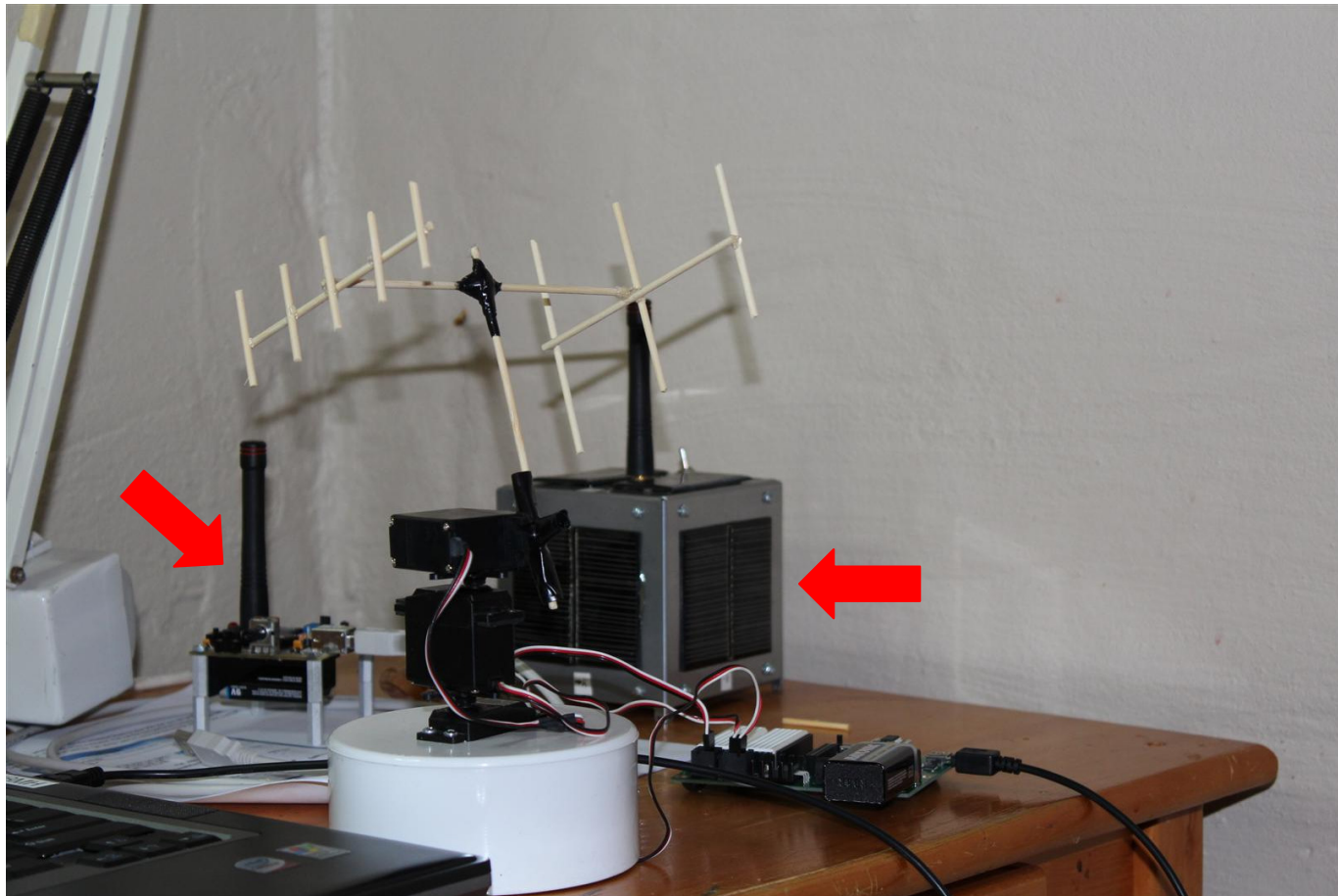
Other Educational Activities

- Tracking simulator-360 azimuth, 180 elevation
 - » Parallax Basic Stamp 2, three servos
 - » Driven by SatPC32, etc. (using EasyComm protocol)
 - » ARRL ETP website



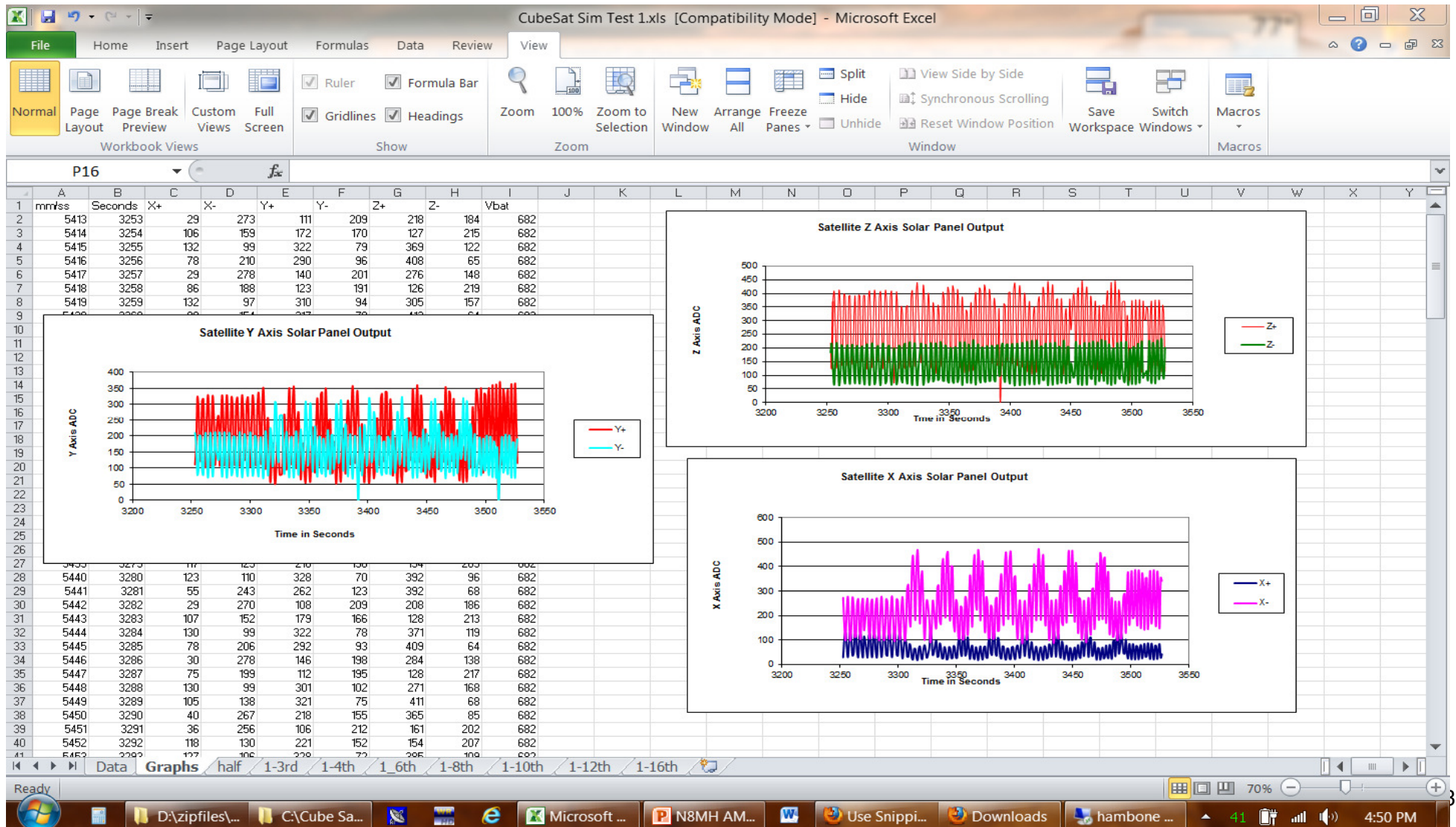
Other Educational Activities

- Cubesat simulator
 - » 2009 Sept/Oct and Nov/Dec issues of AMSAT Journal
 - » ARRL ETP website



Other Educational Activities

● Cubesat simulator data captured





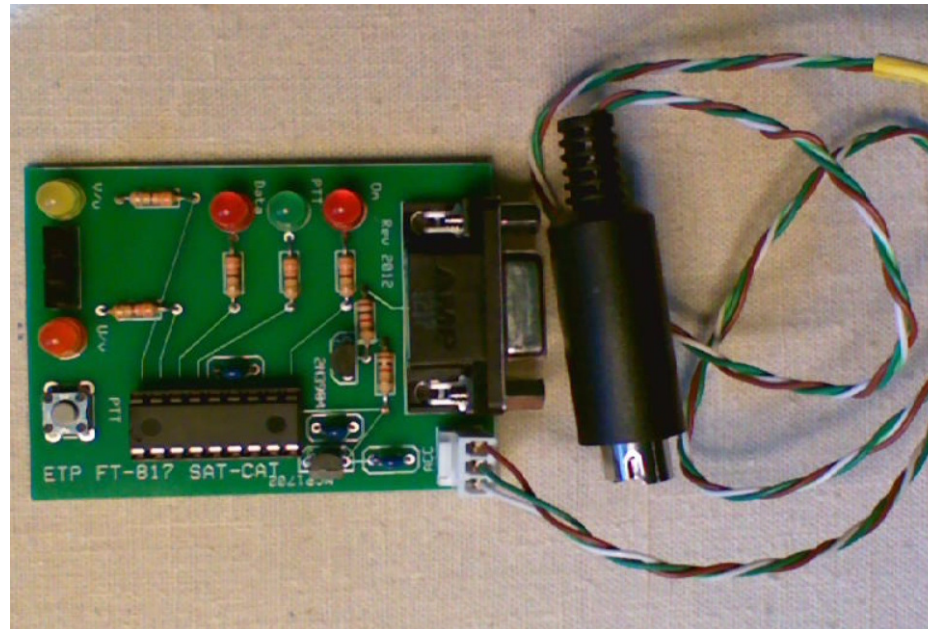
Other Educational Activities

- Useful for hamfests, classrooms, etc.
- Can be “borrowed” from AMSAT for events



Related products and projects

- FT-817 SAT-CAT interface by WA8SME & ARRL-ETP
- October 2012 issue of ARRL's *QST* magazine
 - Pages 40-43
- Facilitate SSB contacts on linear mode satellites (like AO-7, FO-29, VO-52) using single FT-817 radio and SatPC32





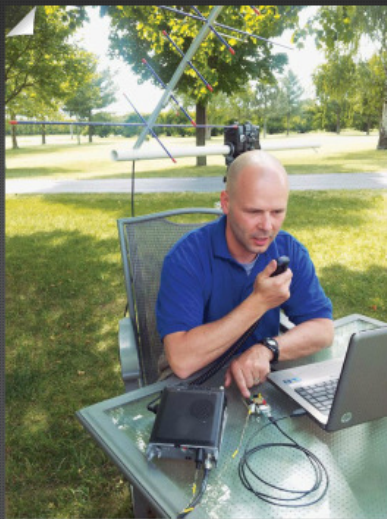
Join or
Renew



40 - 41



QST



Mark Spencer, W8SSME

FM amateur satellites, basically repeaters in the sky, have proven to be very popular. They are easy to access with standard dual band FM radios, a simple directional antenna, a lot of listening and a lot of practice. There are times, however, when the FM birds have become the victims of their own success. The declining number of these high altitude, single channel repeaters has resulted in overcrowding and fierce competition for contacts, marginalizing many who have enjoyed operating the FM satellites, particularly low power and portable stations.

Expand Your Satellite Operations

An alternative to the FM repeating satellites are the wideband analog birds that retransmit a whole sub band of SSB and CW signals. These birds are equally capable and instead of a single channel they use transponder technology that transmits a wider band of frequencies in which multiple contacts can be retransmitted simultaneously (each signal sharing the available bandwidth and RF power of the satellite). The use of transponders and SSB/CW, however, requires more precise frequency control to find the other station, and then to accurately track the other station with its Doppler shift — not a major concern with the FM birds.

Software Brings It All Together

Current satellite tracking software not only tracks the location of the satellite, but also can tune the radio to provide Doppler shift fre-

Satellite CAT Interface for Working the Analog Birds

Expand your satellite operations from FM to SSB and add a new dimension to your skill set.

quency correction (computer aided tuning or CAT). While this helps, it is not essential for operating through the analog birds. It can be argued, however, that being able to hear the downlink while transmitting (full duplex) is critical to successful operations on the analog birds. While the wideband analog satellite alternatives to the FM

birds have a lot of capabilities, they are underutilized. There have been many passes on the analog birds when I have been talking to myself while I have been unable to get a word in edgewise on the next FM bird pass. What gives?

I think the answer includes:

- The lack of readily available (both functional and affordable) all-mode, dual band VHF/UHF, full duplex radios.
- It takes more operator skill and practice to operate the analog birds once the investment is made in the equipment. Shown above is Teachers Institute Instructor Matt Severin, N8MS, communicating through a wideband satellite.

The alternative to an expensive full duplex radio is obtaining two all band transceivers (or a transverter for the downlink in combination with an HF rig for the IF), one for the uplink, the other for the downlink thereby achieving full duplex. Admittedly this is an expensive alternative.

An Interface to Bring It All Together

After this lengthy introduction, I come to the point of this article. What follows is a description of an interface project that will allow you to operate the analog birds with a single non full duplex, all-mode VHF/UHF transceiver. While the circuit and the software are designed for a specific radio (the popular, compact, multimode, Yaesu FT-817 HF/VHF/UHF portable transceiver) and satellite tracking software

package (*SatPC32*), it serves as an example that can be adapted to other radios and other tracking software — left only to the imagination of the builder. This project is not, however, the ultimate alternative to a full duplex all mode transceiver setup, but it will facilitate your exploration of the analog birds more affordably.

First Pick a Radio

I evaluated the suitability of a number of radios for use by teachers to bring space technology into their classrooms while developing the *ARRL Education and Technology Program Teachers Institute-2 Space* (TI-2) course. The rig that floated to the top was the FT-817. This is a relatively affordable low power, all band, all mode transceiver that can be battery operated or operated from a fixed power supply. What

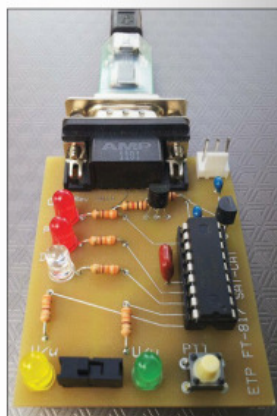


Figure 1 — The Sat CAT Control Interface prototype for use with a Yaesu FT-817.

attracted me most to this transceiver is that it can operate in all modes, has split frequency capabilities (dual VFOs), can be CAT controlled and can operate crossband in the VHF and UHF bands. It is not, however, a full duplex radio.

I apparently am not alone in my favorable opinion of this radio as there are a number of satellite operators who are using this rig (some use two FT-817s to allow full duplex operation). During the TI-2, the teachers use the FT-817 to copy the CW telemetry transmitted by many of the CubeSat satellites, to monitor the analog birds and to make contacts through the FM birds.

Then Pick the Software

The satellite tracking software package that I adopted for the TI-2, as well as for my personal use, is *SatPC32* (there are many other equally capable software packages). *SatPC32* tracks the location of the selected satellites the operator wants to monitor, sends out antenna positioning commands that can be used with a rotator control interface to keep directional antennas pointed at the birds (numerous rotator control interface circuits have been published), sends out radio specific CAT commands to tune the connected radio transceiver to the operating frequencies and keeps those frequencies on track for Doppler correction.

It sounds like *SatPC32* should be able to make a non-full-duplex transceiver work for the analog birds. I have found that the combination of single FT-817 and *SatPC32* is lacking in some respects. The problem is that when updating the receive and transmit frequencies, *SatPC32* toggles between the VFO A and VFO B functions of the radio. This action, which chops up the reception, makes the radio unusable. Because the frequency updates happen regardless of the status of the PTT of the radio, there is a possibility that the operator will key up to transmit while the transceiver is on the VFO assigned for receive. This could blow out a receive preamplifier if one is used. *SatPC32* can control two radios at one time so it works perfectly with two FT-817s, one for uplink, the other for downlink. But with one FT-817 it is lacking.

Enter the Sat CAT Control Interface

The FT-817 Sat CAT Control Interface (prototype shown in Figure 1) described here is designed to intercept the radio tuning commands being sent by *SatPC32* and allow only the receive frequency updates to be passed to the transceiver while in the receive mode and to pass only the updated transmit frequency while the rig is transmitting. This prevents the constant toggling between VFO A and VFO B while receiving, making reception normal and prevents the inadvertent transmission on the receive frequency during

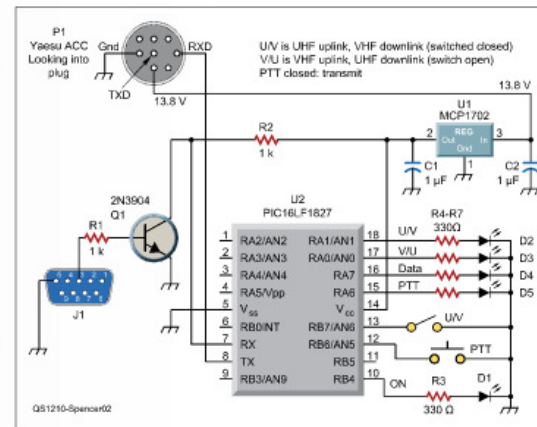


Figure 2 — Schematic diagram and parts list for the interface hardware, based on the PIC16LF1827 microcontroller. Dig-Key parts are available from www.digkey.com

C1, C2 — 1 μ F, 50 V electrolytic capacitor (Dig-Key 445-2865-ND).
D1-D5 — LED (Dig-Key 67-1105-ND (Red), 67-1112-ND (Green)).
J1 — 9-pin D-sub jack (Dig-Key A35107-ND).
P1 — Plug to match radio ACC jack (Dig-Key CP-2080-ND).

Q1 — 2N3904 or equivalent transistor (Dig-Key 2N3904FS-ND).
R1, R2 — 1 k Ω , 1/4 W resistor.
U1 — MCP1702 3.3 V regulator IC (Dig-Key PIC16LF1827-I/P-ND).
U2 — PIC16LF1827 microcontroller (Dig-Key MCP1702-3302E/TO-ND).

a contact. The interface consists of two parts, the hardware and the software.

Control Interface Hardware

The interface hardware (Figure 2) is based on the PIC16LF1827 microcontroller. This device has USART functionality that makes it easy to connect the microcontroller to other devices serially. The output of the computer running *SatPC32* is at serial RS232 levels (± 12 V) while the input to the PIC16LF1827 is at transistor-transistor logic (TTL) voltage levels (3.3 V), so some voltage level conversion is required. This is accomplished by the 2N3904 NPN transistor and current limiting resistors. The CAT input to the FT-817 is at TTL levels, so no voltage conversion between the PIC and the radio ACC connection is needed. There are a number of indicator LEDs mounted on the board as labeled in the circuit diagram for operator convenience and for operation and mode verification. The PTT switch of the circuit is used instead of the microphone PTT switch on the FT-817 microphone.

Control Interface Software

The real meat of the project is in the microcontroller software. The microcontroller software for this project is written in the C programming language and is available for

download on the QST-in-Depth website as well as from the author upon e-mail request.¹ Before the logic of the microcontroller software can be discussed, a review of the output CAT command format from *SatPC32* is in order. This would be a good time to dig out the *FT-817 Operator's Manual* and review pages 70-73. (Those who are adapting this project to a different transceiver will have to study their specific radio CAT command format and author software to match.)

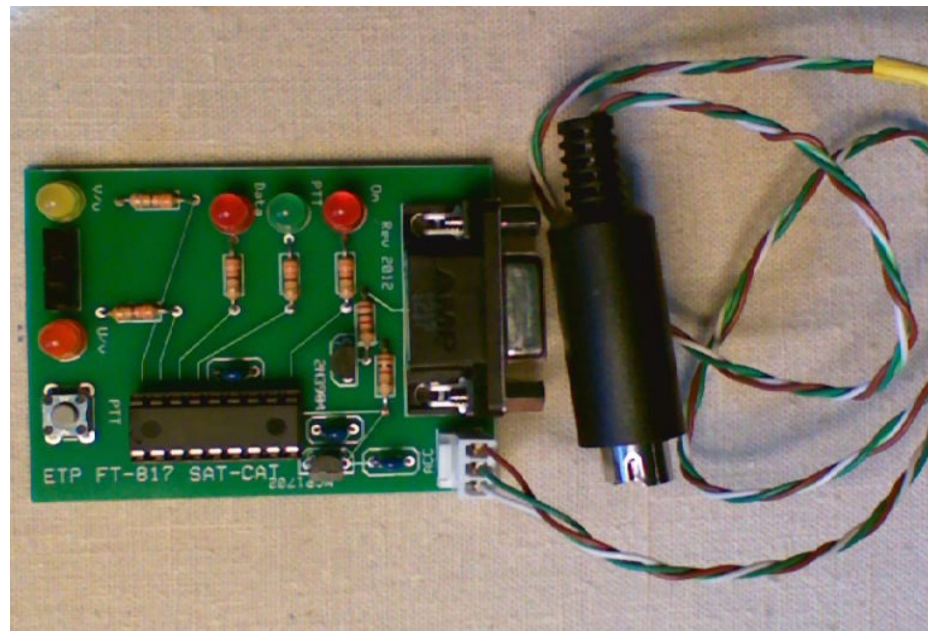
To control the FT-817 via a computer, specific commands in a specific format must be transmitted by the computer to the radio ACC jack through a CAT interface. The Yaesu interface is the CT-62 option — basically a voltage level converter between RS232 and TTL levels. These commands are contained in a 5 byte structure with the individual bytes sent LSB first, MSB last at user specified baud rates (this interface is based on 9600 baud). The first 4 bytes of the command structure are parameters (data such as frequency to be set) or dummy place-fillers and the last byte is the actual command *Opcode* as shown in Table 1.

The decimal values of the parameters are

¹www.arrl.org/qst-in-depth

Related products and projects

- Bare board+programmed PIC - \$20 (\$22 shipped)
- Full kit of parts! \$35 (\$40.50 shipped)
- \$5 per sale goes towards AMSAT Fox program!!
- ***Several boards and full kits available for sale here at Symposium! (See me)***



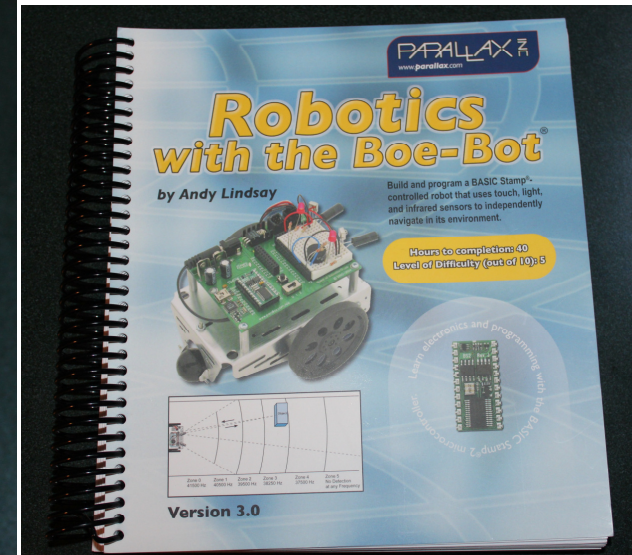
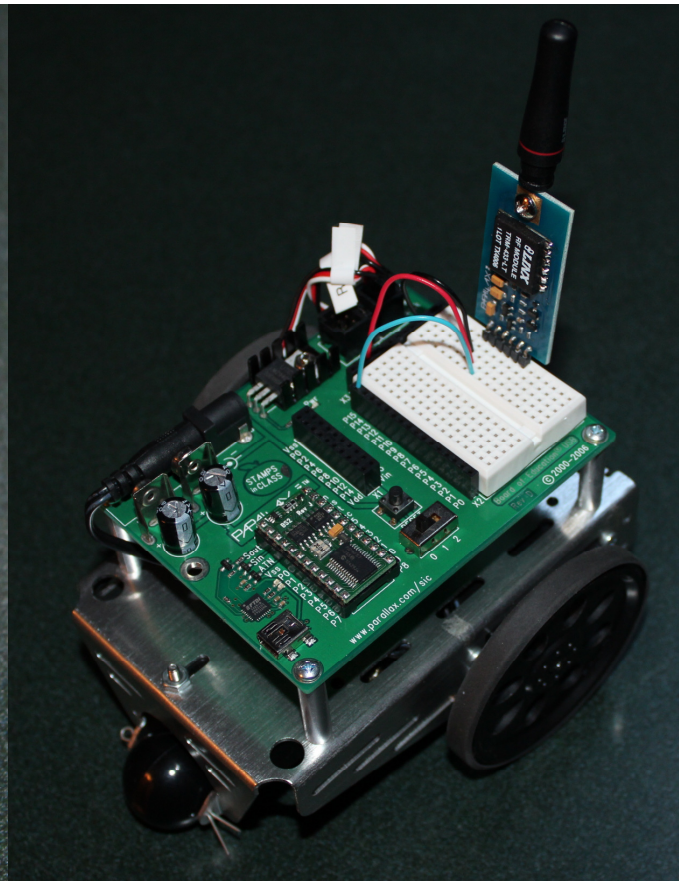
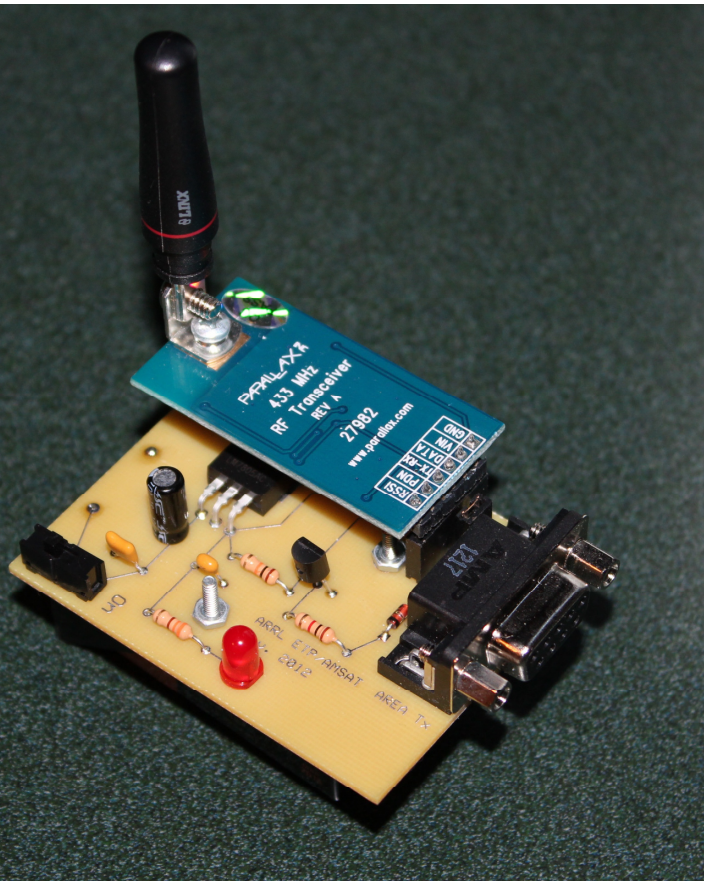


Related products and projects

- SAT-CAT Boards or kits may be ordered from the ARRL Education & Technology Program. To order contact us at etp@arrl.org, or contact Mark Spencer at WA8SME@arrl.org, or mail in your request.
- Checks should be made payable to the ARRL Education & Technology Program.
- The order must include the following information:
 - # of SatCat boards or SatCat kits requested
 - shipping address
 - name and personal contact information: email address and phone number
- Send the order and payment to:
- ARRL Education Services
- 225 Main Street, Newington, CT 06111
-
- Additional donations to ARRL ETP and/or to AMSAT are always welcome!

Other Educational Activities

- MAREA- the Mars-lander ARISS Robotics Exploration Activity





Other Educational Activities

- MAREA- the Mars-lander ARISS Robotics Exploration Activity
 - » Parallax BS2 based BOE-BOT, local RF link
 - » Simulates transmission/reception of ground station commands through space to control rover vehicle
 - » Command (text) from ground station->packet digipeat through ARISS on ISS->receive on ground station->local RF link sends command to Rover->movement executed
 - » Local testing/experimentation easy with only loopback audio cable (soundcard out->mic in)

Other Educational Activities

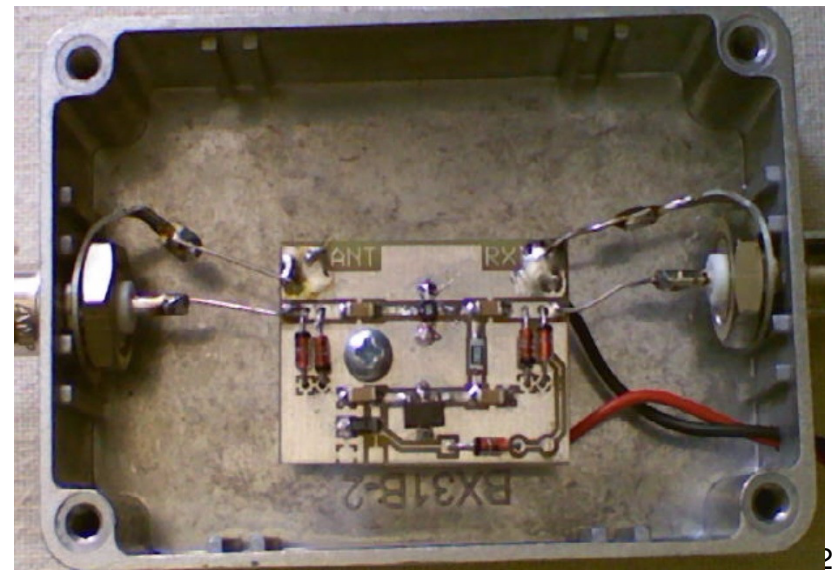
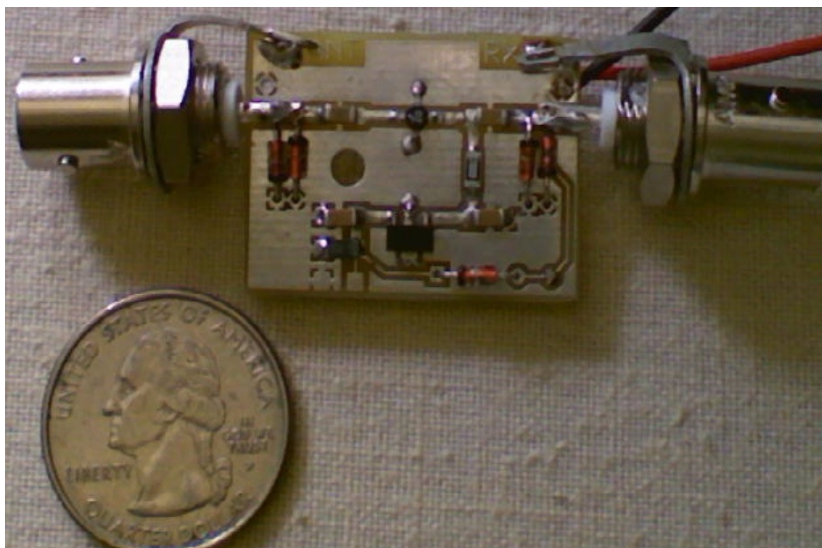
- MAREA- the Mars-lander ARISS Robotics Exploration
- Live demo via ARISS on ISS!





Sneak Preview! Another WA8SME project

- Broadband Preamplifier (rcv only)
- Great for receiving on 2M and 70cm
- ***To be offered in AMSAT Store (mid to late November)***
- Full details in next Journal!





What are some specific educational needs?

- Web content person for AMSAT's education web pages
 - » Maintain calendar of amateur radio youth events
- Archivist/publicist of satellite educational activities (photos, stories for Journal, press, videos)
- Web researcher to “mine,” collect, and organize existing lesson plans/ideas that may prove useful



What are some specific educational needs?

- K-12 educators that can write lesson plans/ideas using satellite telemetry, etc. related to science, technology, engineering, and math (STEM).
 - » ARISSat-1 telemetry data needs to be used in the classroom!
 - » ARISS and satellite related lesson plans
- Mentors and ground station operators (with equipment!) for ARISS contacts



What can *you* do to help?

- Maintain AMSAT membership!
- Join the AMSAT-EDU mailing list
(www.amsat.org for details/instructions)
- Volunteer for a specific task! n8mh@amsat.org
- Educators: We need lesson plans/ideas related to satellites and amateur radio
- Refer educators to sign up for ARRL Teacher's Institute programs!



What can *you* do to help?

- Contact family members, friends that are educators and get them involved with satellite operations
- Look for opportunities to engage youth, and document it (photos, articles, press)
- Give a demo at a local club meeting
- Become active in ARISS: mentors and ground station operators (with equipment!) are needed



Want to help?



- Contact me: Mark Hammond, N8MH@amsat.org